UNIVERSITI SAINS MALAYSIA

First Semester Examination
2014/2015 Academic Session

December 2014 / January 2015

EMH 332 – Applied Thermodynamics
[Termodinamik Gunaan]

Duration : 3 hours
[Masa : 3 jam]

Please check that this paper contains **SIX** printed pages, **THREE** pages appendix and **SIX** questions before you begin the examination.

*[Sila pastikan bahawa kertas soalan ini mengandungi **ENAM** mukasurat, **TIGA** mukasurat lampiran dan **ENAM** soalan yang bercetak sebelum anda memulakan peperiksaan.]*

Appendix/*Lampiran :*

1. Formula for Internal Combustion Engine [3 pages/mukasurat]

INSTRUCTIONS : Answer **FIVE (5)** questions only.

*[**ARAHAN** : Jawab **LIMA (5)** soalan sahaja.]*

Answer questions in English OR Bahasa Malaysia.
[Jawab soalan dalam Bahasa Inggeris ATAU Bahasa Malaysia.]

Answer to each question must begin from a new page.
[Jawapan bagi setiap soalan mestilah dimulakan pada mukasurat yang baru.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

Thermodynamic Property Table is provided.
Jadual Sifat Bendalir Termodinamik adalah dibekalkan.

Q1. [a] By the help of diagram, explain how the Dalton's law can be used for real gases with high pressure.

Dengan bantuan gambarajah, terangkan bagaimana hukum Dalton boleh digunakan bagi gas sebenar dengan tekanan tinggi.

(30 marks/markah)

[b] Using the ideal gas equation and the Dalton's law, show that the ratio of partial pressure (P_i/P) can be written as:

Dengan persamaan gas unggul dan hukum Dalton, tunjukkan nisbah tekanan separa (P_i/P) boleh dituliskan sebagai:

$$\frac{P_i}{P} = \frac{V_i}{V} = \frac{n_i}{n}$$

(30 marks/markah)

[c] A gas mixture in an engine cylinder has 12% CO_2, 11.5% O_2 and 76.5% N_2, by volume. The mixture at 1000°C expands reversibly, according to $Pv^{1.25}$= constant, to 7 times its initial volume. Determine:

Suatu campuran gas di dalam sebuah enjin silinder mempunyai 12% CO_2, 11.5% O_2 dan 76.5% N_2, mengikut isipadu. Campuran adalah pada 1000°C mengembang secara boleh-balik mengikut **$Pv^{1.25}$=** malar, sehingga 7 kali isipadu awal. *Tentukan:*

[i] The work done per unit mass

Kerja terlaku per unit jisim

[ii] Heat transfer per unit mass

Pemindahan haba per unit jisim

(40 marks/markah)

Q2. [a] Distinguish between specific humidity and relative humidity.

Bezakan di antara kelembapan tentu dan kelembapan relatif.

(20 marks/markah)

[b] Air at 10°C and 50% relative humidity flows at the rate of 500kg/s is blowing over a heating coil through which saturated steam (100°C) flows. As an indirect heat exchanger between the steam and the air takes place, the steam leaves as condensate at 80°C. Air is heated to 30°C in the process. Determine:

Udara pada 10°C and 50% kelembapan relatif mengalir pada kadar 500kg/s ditiup melalui sebuah lengkaran pemanas yang mana wap tepu (100°C) mengalir. Sebagai penukar haba secara tak langsung di antara wap dan udara berlaku, wap keluar sebagai bahan terpeluwap pada 80°C. Udara dipanaskan sehingga 30°C dalam proses ini. Tentukan

[i] sensible heat transfer rate to the air

kadar pemindahan haba deria pada udara

[ii] mass flow rate of the steam

kadar aliran jisim bagi wap

(40 marks/markah)

[c] Two air streams:

Stream 1: 1800m^3/h, dry bulb temperature of 15°C and wet bulb temperature of 13°C

Stream 2: 720m^3/h, dry bulb temperature of 25°C and wet bulb temperature of 18°C are mixed adiabatically in a duct. At the exit, calculate:

Dua aliran udara:

Aliran 1: 1800m^3/h, suhu bebuli kering adalah 15°C suhu bebuli basah adalah 13°C

Aliran 2: 720m^3/h, suhu bebuli kering adalah 25°C suhu bebuli basah adalah 18°C adalah tercampur secara adiabatik di dalam sebuah saluran. Pada salur keluar, kirakan:

[i] The dry bulb temperature

Suhu bebuli kering

[ii] The wet bulb temperature

Suhu bebuli basah

(40 marks/markah)

Q3. [a] Distinguish between proximate analysis and ultimate analysis.

Bezakan di antara analisis proksimat dan muktamad

(20 marks/markah)

[b] Ethane gas (C_2H_6) obtained from a certain source is burnt with dry air in stoichiometric equation and calculate the air-fuel ratio.

Gas etana (C_2H_6) didapati daripada suatu sumber adalah terbakar dengan udara kering mengikut persamaan stoikiometri dan kirakan nisbah udara-bahan api.

(30 marks/markah)

[c] Methane is combusted with 100% theoretical dry air at 25^{o}C and 101.3kPa. Calculate:

Metana dibakar dengan 100% teori udara kering pada 25^{o}C dan 101.3kPa. Kirakan:

[i] enthalpy of reaction

entalpi bagi tindakbalas

[ii] dew point temperature of the products

suhu titik embun bagi produk

[iii] Heat of combustion

Haba pembakaran

[iv] Low heating value (LHV)

Nilai pemanasan rendah (LHV)

[v] High heating value (HHV)

Nilai pemanasan tinggi (HHV)

(50 marks/markah)

Q4. [a] Draw the schematic diagram, P-V plane of a four-stroke engine, and explain their processes.

Lukiskan rajah skematik, satah P-V bagi sebuah enjin empat lejang, dan terangkan proses-proses berkenaan.

(30 marks/markah)

[b] In the indicated diagram, briefly discuss the performance map at different piston speed for gasoline engine.

Dalam gambarajah tertunjuk, bincang secara ringkas peta prestasi pada perbezaan halaju omboh bagi enjin petrol.

(30 marks/markah)

[c] An 8-cylinder engine, 9.5cm (bore) x 8cm (stroke), 4-stroke, gasoline engine running at 3000rpm has a volumetric efficiency of 75% and air-fuel ratio of 16. The inlet condition is 101kPa and 30^{o}C, calculate the fuel consumption used.

Sebuah enjin 8-silinder, 9.5cm (jara) x 8cm (lejang), 4-lejang, enjin petrol beroperasi pada 3000rpm mempunyai kecekapan isipadu 75% dan nisbah udara-bahan api adalah 16. Keadaan masukan adalah 101kPa dan 30^{o}C, kirakan penggunaan bahan api yang digunakan.

(40 marks/markah)

Q5. [a] Discuss at least five (5) advantages and disadvantages of Diesel engine.

Bincangkan sekurang-kurangnya lima (5) kebaikan dan keburukan bagi enjin Diesel.

(30 marks/markah)

[b] In the indicated diagram, briefly discuss the performance map at different piston speed for Diesel engine.

Dalam gambarajah tertunjuk, bincang secara ringkas peta prestasi pada perbezaan halaju omboh bagi enjin Diesel.

(30 marks/markah)

[c] A truck uses an air Diesel engine cycle with a compression ratio of 16. Air is at 30^{o}C and 100kPa at the beginning of the compression process and the maximum cycle temperature is 2500K. Calculate:

[i] the cut-off ratio
[ii] the specific heat transfer, and
[iii] the cycle efficiency.

Sebuah trak menggunakan kitar enjin udara Diesel dengan nisbah mampatan adalah 16. Udara adalah pada 30 ^{o}C dan 100kPa pada permulaan proses mampatan dan suhu maksimum kitar adalah 2500K. Kirakan:

[i] Nisbah potongan
[ii] Haba terpindah tentu, dan
[iii] Kecekapan kitar

(40 marks/markah)

Q6. [a] With the help of diagrams, explain the working principles of a reciprocating compressor.

Dengan bantuan gambarajah, terangkan prinsip kerja bagi pemampat salingan.

(30 marks/markah)

[b] A single acting 2 stage compressor draws in 8.5m^3/min of free air and compresses it to 4MPa. The compressor runs at 300rev/min. The atmospheric conditions are 101.3kPa and 15^{o}C. There is an intercooler between stages which cools the air back to 15^{o}C. The polytropic index for all compressors is 1.3. The volumetric efficiency is 90% for the low pressure stage and 85% for the high pressure. Ignore the effect of the clearance volume and leakage, calculate:

Sebuah pemampat tindakan tunggal 2 peringkat mengambil 8.5m^3/min udara bebas dan memampatkannya sehingga 4MPa. Pemampat beroperasi pada 300 putaran/min. Keadaan atmosfera adalah 101.3kPa dan 15^{o}C. Terdapat sebuah penyejuk-antara di antara peringkat yang menyejukkan semula udara pada 15^{o}C. Indeks politropik bagi semua pemampat adalah 1.3. Kecekapan isipadu ialah 90% bagi peringkat tekanan rendah dan 85% bagi peringkat tekanan tinggi. Abaikan kesan isipadu ruang dan kebocoran, Kirakan:

[i] The intermediate pressure for minimum indicated work

Tekanan antara bagi kerja tertunjuk minimum

[ii] The theoretical indicated power for each stage

Kuasa tertunjuk teori bagi setiap peringkat

[iii] The heat rejected in each cylinder

Haba terbebas bagi setiap silinder

[iv] The heat rejected by the intercooler

Haba terbebas oleh penyejuk-antara

[v] The swept volume of both stages

Isipadu tersapu bagi kedua-dua peringkat

Explain also the effect on your answer of not ignoring the clearance volume and leakage.

Terangkan juga kesan ke atas jawapan anda dengan tidak mengabaikan isipadu ruang dan kebocoran.

(70 marks/markah)

Formula for Internal Combustion Engine

The compression ratio, r:

$$r = \frac{V_{\max}}{V_{\min}}$$

The mean effective pressure, MEP

$$MEP = \frac{W_{net}}{V_{\max} - V_{\min}} = \frac{w_{net}}{v_{\max} - v_{\min}}$$

The indicated mean effective pressure, pi

$$p_i = \frac{net\_area\_of\_diagram}{length\_diagram} \times cons\tan t$$

Work done per cycle = $p_i \times A \times L$

The indicated power, ip:

$$ip = p_i AL \times (cycles/time)$$

For four-stroke engine:

$$ip = \frac{p_i ALNn}{2}$$

For two-stroke engine:

$$ip = p_i ALNn$$

Where n is the no. of cylinders.

Brake power (bp)

This is to measure the engine output. The engine is connected to the break or dynamometer.

T= WR

The brake power is then given by

$$bp = 2\pi NT$$

Friction power (fp) and mechanical efficiency, η_m

The difference between ip and bp:

Fp = ip – bp

The mechanical efficiency:

$$\eta_m = \frac{bp}{ip}$$

For multi cylinder engines such as four cylinder engine, the bp

$$bp = (ip_1 - L_1) + (ip_2 - L_2) + (ip_3 - L_3) + (ip_4 - L_4)$$

Break mean effective pressure (bmep)

The bp is obtained using dynamometer,

$$bp = \eta_m \times ip$$

For a four-stroke engine,

$$bp = \frac{\eta_m \times p_i ALNn}{2} \quad \text{or}$$

$$bp = \frac{p_b ALNn}{2} \quad \text{where} \quad p_b = \eta_m \times p_i$$

For the frictionless engine, the bmep

$$\frac{p_b ALNn}{2} = 2\pi NT$$

Thus, $p_b = K \times T$ where K = constant

The overall efficiency of the engine is given by the brake thermal efficiency,

$$\eta_{BT} = \frac{bp}{m_{fuel} \times Q_{net,v}}$$

Specific fuel consumption, sfc

The specific fuel consumption (sfc) is the mass flow rate of fuel consumed per unit power output,

$$sfc = \frac{m_{fuel}}{bp}$$

The indicated thermal efficiency, η_{IT} is defined as

$$\eta_{IT} = \frac{ip}{m_{fuel} \times Q_{net,v}}$$

Volumetric Efficiency, η_V

$$\eta_V = \frac{V}{V_S}$$